Negative Sequence Controllers to Reduce Power Oscillations During Electric Faults in the Offshore Wind Power Grid

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Negative Sequence Controllers to Reduce Power Oscillations During Electric Faults in the Offshore Wind Power Grid

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Vestas No.1 in Modern Energy

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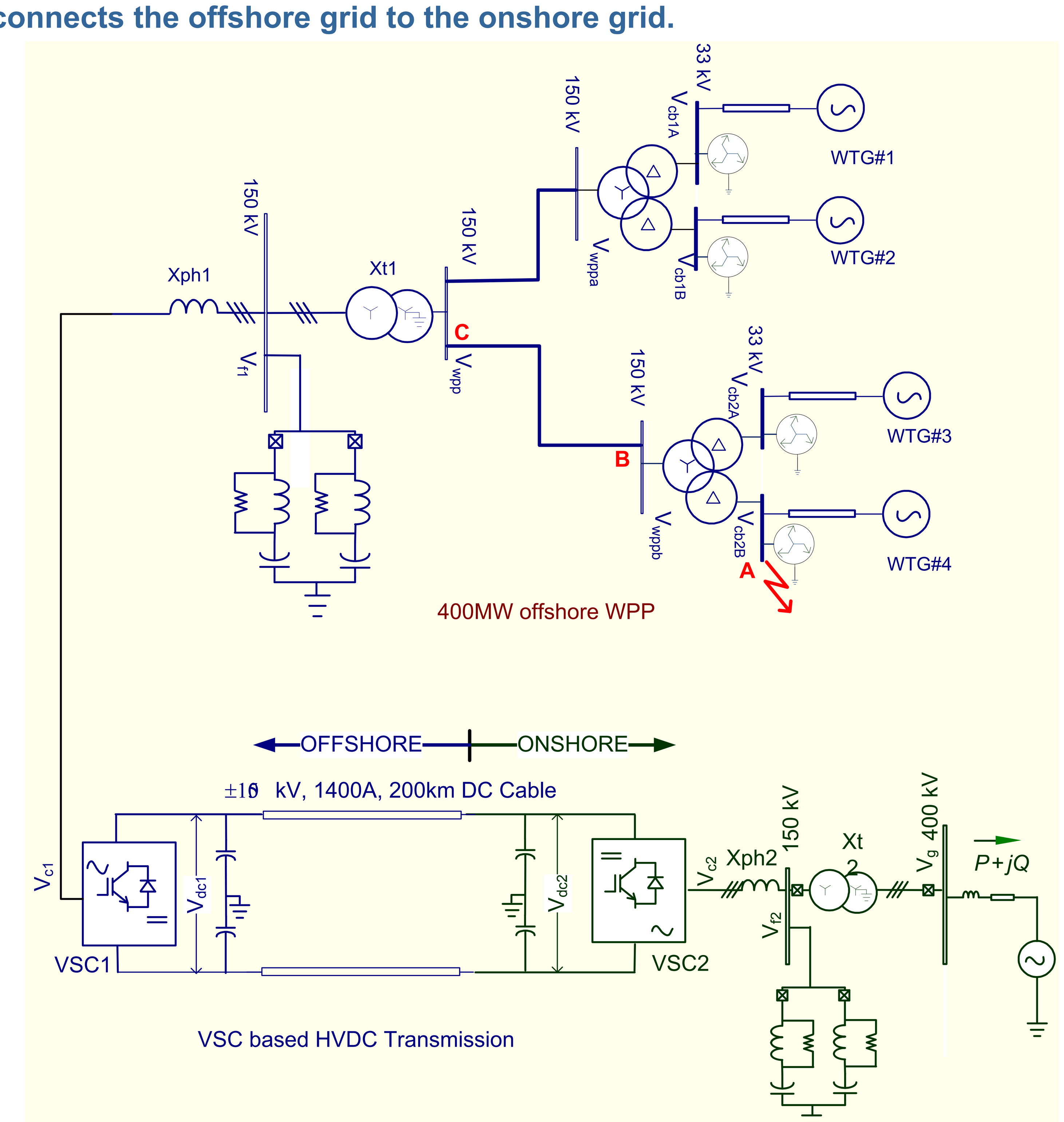
Main Objectives:

To reduce the power oscillations and subsequent dc voltage oscillations in the VSC-HVDC transmission connecting an offshore wind power plant to an onshore grid.

- ► To develop a PSCAD/EMTDC simulation model of an offshore WPP with VSC-HVDC connection to the Onshore grid.
- ► To simulate the symmetrical and asymmetrical faults in the offshore grid and study the oscillations in the VSC-HVDC transmission system
- ► To estimate the content of positive and negative sequence voltage and current components in real time using DSOGI filters.
- ► To propose a negative sequence current control algorithm and compare the results with the negative sequence voltage control algorithm.

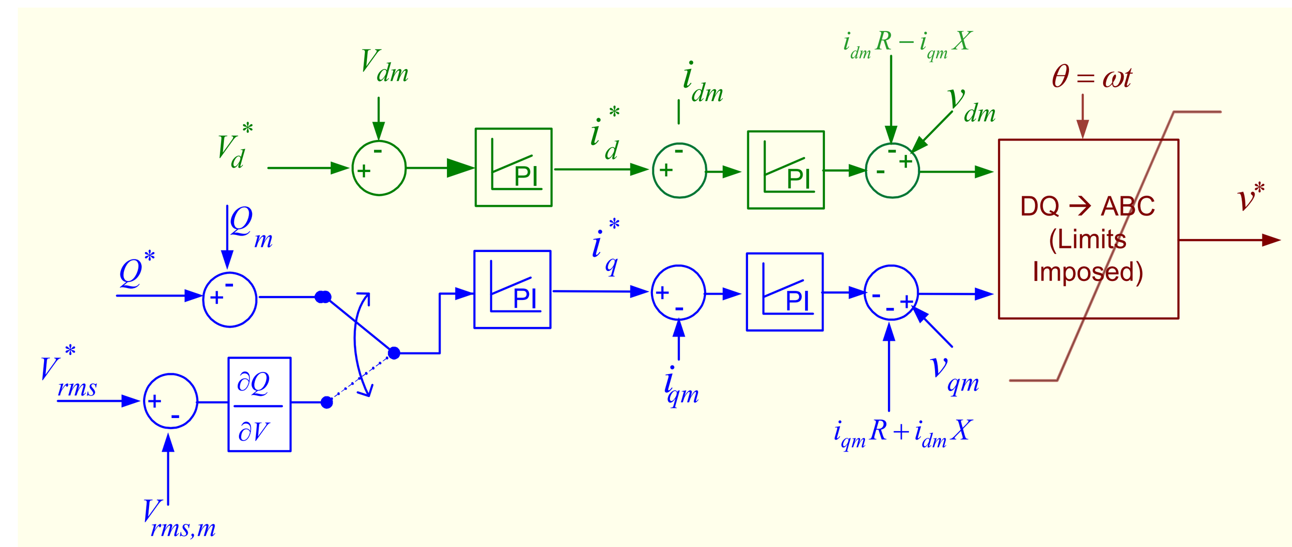
System Layout and Single Line Diagram

A 400MW offshore wind power plant has been modeled as 4 aggregated wind turbines with full scale converters. VSC-HVDC transmission connects the offshore grid to the onshore grid.

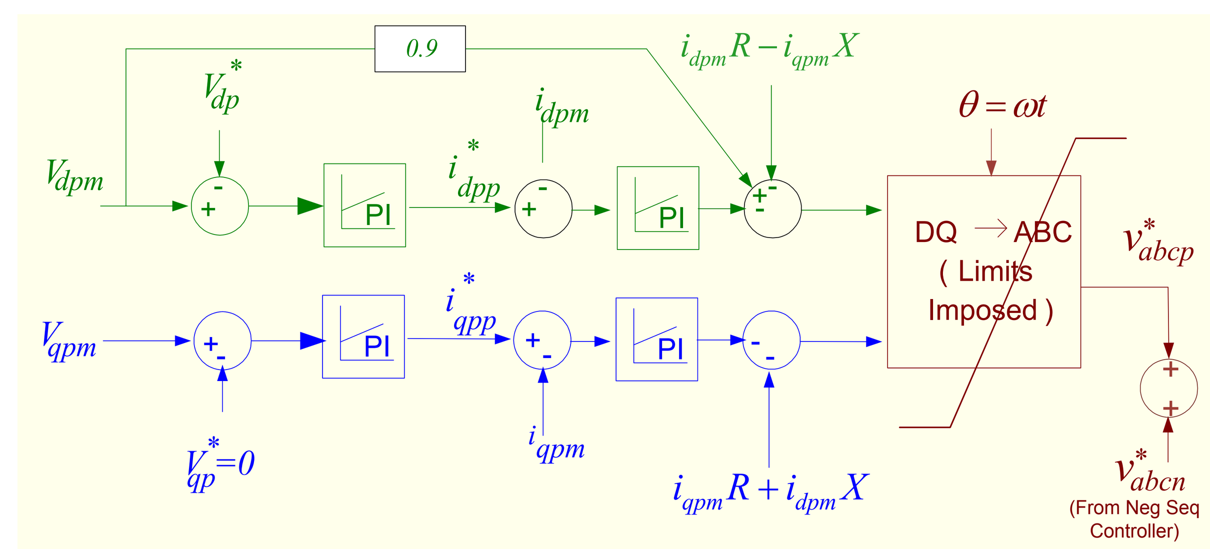


VSC-HVDC Controllers

Onshore VSC Controller: **Control of dc voltage and reactive power or ac voltage measured at the point of common coupling.**

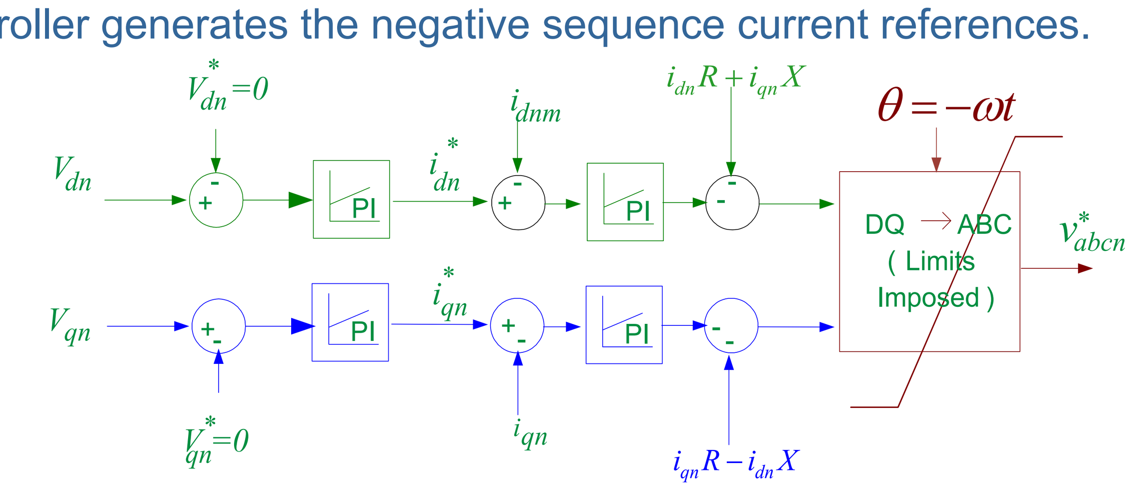


Offshore VSC Controller: **Control of offshore grid terminal ac voltage and frequency.**



Negative Sequence Controller
(for offshore VSC Controller)

Negative Sequence Voltage Control: Negative sequence voltage references in the d and q axes are set to 0. The outer PI controller generates the negative sequence current references.



Negative Sequence Current Control: Negative sequence current references in the α and β axes are solved from the equations given below, in the stationary reference frame,

$$v_{\alpha n} i_{\alpha p} + v_{\alpha p} i_{\alpha n} + v_{\beta n} i_{\beta p} + v_{\beta p} i_{\beta n} = 0$$

$$v_{\beta n} i_{\alpha p} + v_{\beta p} i_{\alpha n} - v_{\alpha n} i_{\beta p} - v_{\alpha p} i_{\beta n} = 0$$

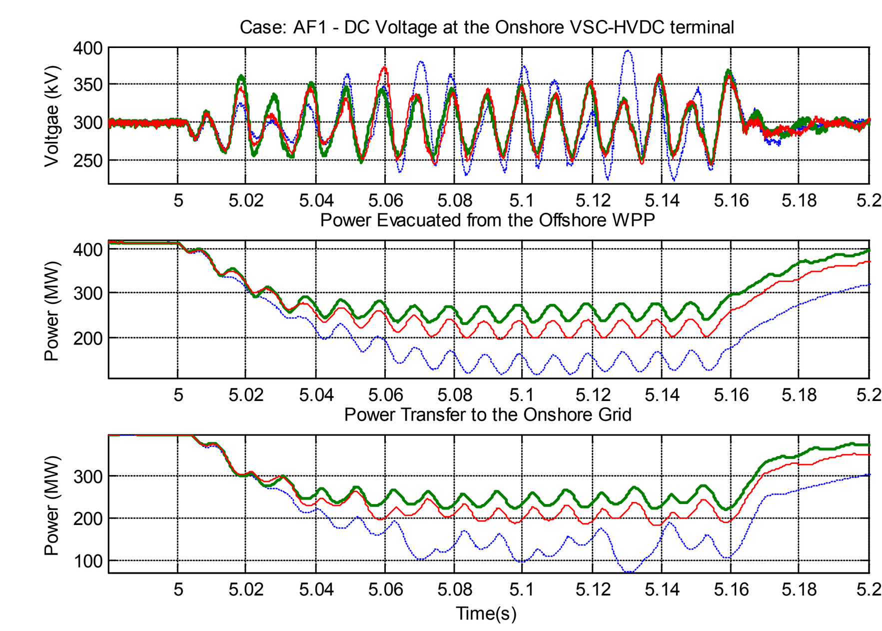
The –ve sequence current references are transformed into the d-q axes components before applying to the controller.

Fault Simulations and Comparison of the Controller Performance

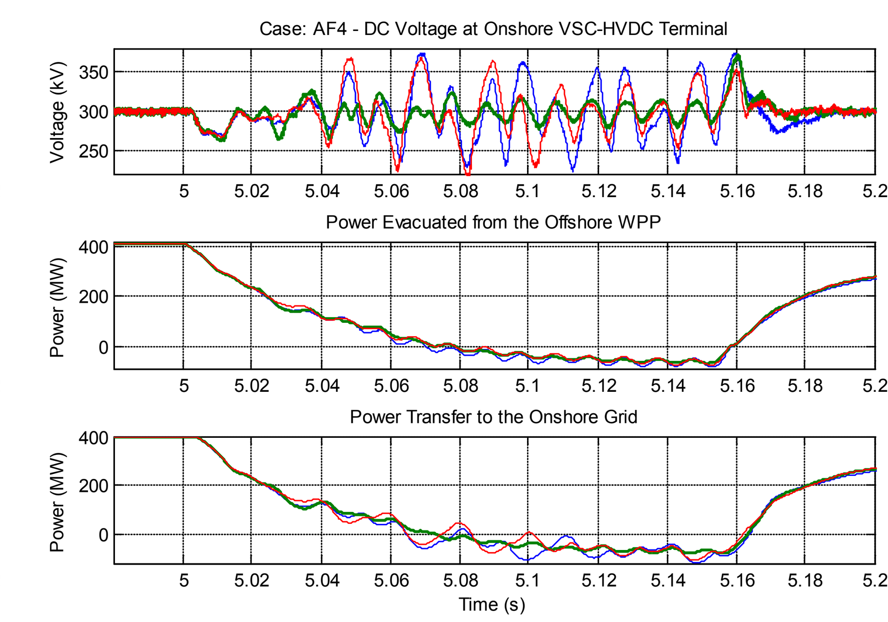
Electrical faults of both symmetric (LLLG & LLL) and asymmetric (LG, LLG & LL) types were simulated at points A/B/C (shown in the layout).

Fault resistance of magnitude 0.10 pu and duration 150ms was used.

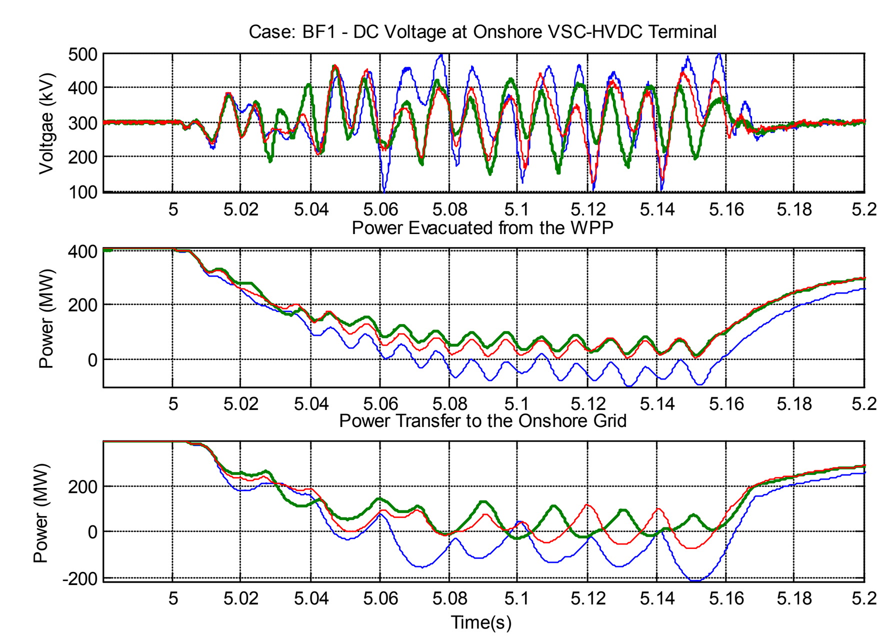
DC voltage at the onshore VSC-HVDC terminal, power evacuated from the offshore grid and power injected into the onshore grid have been shown below for some selected cases.



Plots for L-G fault at point A



Plots for LL-G fault at point A



Plots for L-G fault at point B

Legends:

1. Without negative sequence controller
2. With negative sequence voltage controller
3. With negative sequence current controller

Conclusion

- ► Negative sequence current controller is effective in decreasing the power and voltage oscillations in the VSC-HVDC system.
- ► Even in the case of symmetric faults, the peak overvoltage arising out of sudden power unbalance is reduced.
- ► However, the power and voltage oscillations could not be elimiated completely.

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